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THE SUPPLY OF ENGINEERS AND SCIENTISTS

by

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ERRATA

p. 2. The third and fourth lines from the bottom should read: supply curves are defined into a "short period" in which only those with training and currently in the occupation can offer work and a "long period" in

p. 8. Male first-time college enrollment for 1952-53 is: 323,673

p. 11. The next to the last line of the second paragraph should read: engineers graduated three years later declined for freshmen entering

p. 12. Entries in Percent of All Men's degrees should be:

Engineers	Mathematics[a]	Physical Science[b]	Mathematics, Physical Science, and Engineering
12.0	1.6	4.3	17.9

p. 18. Line 6 of the second paragraph should read:

where college algebra, trigonometry, and, where possible, analytic geometry or

in the last line: Ginzberg should read: Ginzberg

p. 22. Line 3 should read: trainees salaries (Table 5). In short, freshmen responded to an engineering

p. 24. The third line from the bottom should read:

such as "professor of engineering" and "professor of physics," the scientist might

p. 27. "new Math" should read: "New Math"

p. 29. (Table , below). should read: (Table 12, below).

in the next to the last line omit: considerably

p. 41. Line 5 should read:

space age. As a result, many of the less commited science students

p. 46. 6th line from bottom: omit the comma after "nongraduates."

2nd line from bottom "the statement" should read: this statement

ERRATA

(continued)

p. 48. The 9th line from the bottom should read:

1962, the proportion of all male graduates in mathematics has risen sharply.

p. 50. No. 17, authors should be:

Shapero, Albert, Richard P. Howell, and James R. Tombaugh

The Supply of Engineers and Scientists

by Hugh Folk*

By "supply" the economist means a schedule of the quantity of a factor (or commodity) that will be offered at various prices. The supply of a factor will depend not only on its own price, but on the price of related complementary and substitute factors. Thus it is said that the supply of a single factor is a function not only of its own price, but of the prices of related factors. There are variables other than price which influence labor supply, of course. The most important of these may be the workers' taste for the job or "noneconomic" factors. One of the principal reasons that a useful economic theory of occupational choice has not been developed is that aspects of jobs which are commonly denominated as non-economic appear to be important in determining occupational choice.

In this paper we shall concentrate on some aspects of the supply of engineers and scientists. The first section points out the limitations of conventional supply analysis for our purposes. The second section presents data on the trends in engineering and science enrollments and degrees. The third section presents data on the earnings of engineers and scientists. The fourth section draws on the previous sections to identify and evaluate the causes of the changes in engineering and scientific enrollments and degrees.

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*This paper owes a great debt to the industry and advice of Mr. David Greytak. I have made considerable use of his essay "Engineering Enrollments and Degrees, 1946-63" (on file with the Department of Economics, Washington University). Responsibility for the conclusions rests solely with the author. This research was supported by NASA Grant NsG-342.

The fifth section analyzes the patterns of occupational choice of persons who have completed engineering and science educations. The sixth section deals with nongraduates who are the principal substitute for trained engineers. The seventh section includes the summary and conclusions.

I. Supply Curves

The occupational supply curve is a schedule or function relating the number of workers in an occupation to the salary or wage of that occupation. The conventional supply curve is assumed to be positively sloped indicating that an increase in salary will lead to an increase in the number of persons offering to work in the occupation (see fig. 1). The upward slope of the supply curve depends on the assumption of <u>ceteris</u> <u>paribus</u> ("other things being equal") that is commonly made. Among the "other things" that obviously should not change are salaries in competing or similar occupations. Since wages and salaries in most occupations have recently shown a steady upward drift of two percent a year or more, it seems reasonable to attempt to control for the upward drift by using the ratio of the salary of the occupation that interests us to the salary of some reference group (which we will call "relative salary") as the indicator of "price" on the supply curve.

The conventional classification of supply periods (or periods over which supply curves are defined) into a "[illegible] period" in which only those with training and currently in the occupation can offer work, a "[illegible] period" in which the number of persons being trained and the number of training facilities can be changed is not very useful for our purposes.[1/]

1/ For an interesting application of conventional supply analysis to an occupation see Yett (18).

Instead of the conventional period classification, we will confine entirely to a set of short-run supply curves:

(1) The <u>short-run supply curve</u> relates quantity to relative salary over an unspecified short period. In a very short period, of course, the supply will be almost completely inelastic.[2/] As the length of the period increases, the supply will become more elastic.

(2) The <u>net additions supply curve</u> relates the difference between the <u>attrition curve</u> and the <u>gross additions curve</u> to the relative salary in the occupation.

(3) The <u>attrition curve</u> relates loss from the occupation owing to death, disability, retirement, and net outward mobility to the relative salary.

(4) The <u>gross additions curve</u> relates the number of newly trained persons (that have never before worked in the occupation) entering the occupation to the relative salary.

(5) The <u>occupational training curve</u> relates the number of persons entering training for the occupation to the relative salary in the occupation.

The interrelations of the curves for a hypothetical labor market are shown in fig. 2. Fig. 2a shows that the short-run supply curve is equal to total employment plus the net additions supply curve. Fig. 2b shows the net additions supply curve as the difference between the gross additions curve and the attrition curve. Fig. 2c shows the gross additions curve and the occupational training curve of the relevant previous period (i.e. the period in which trainees would have had to begin training if they were to complete their training during the period to which the gross additions curve applies.) The

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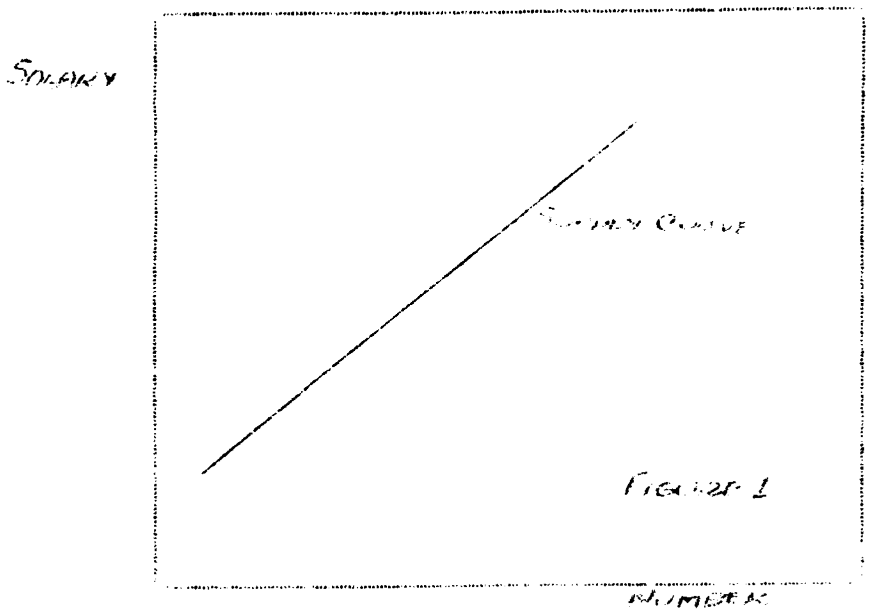
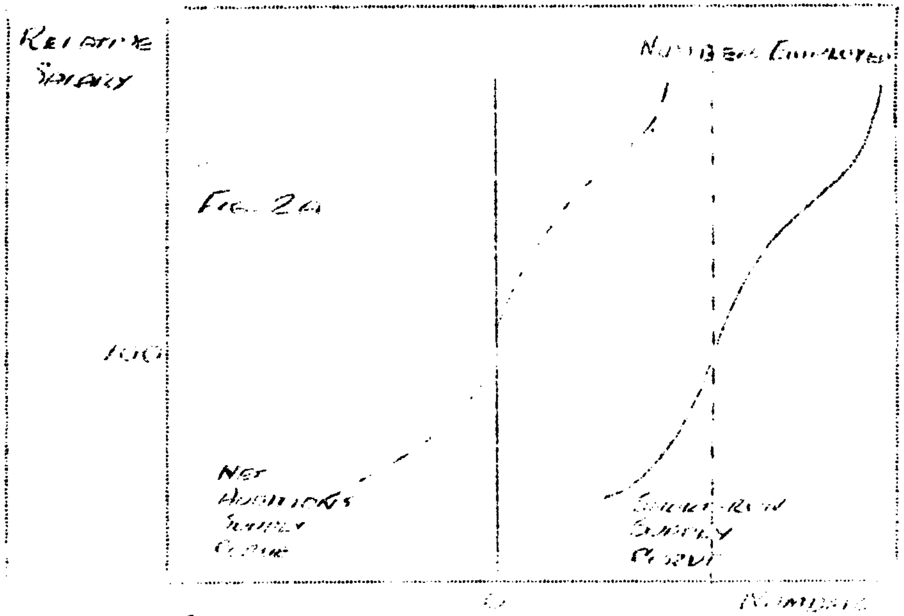
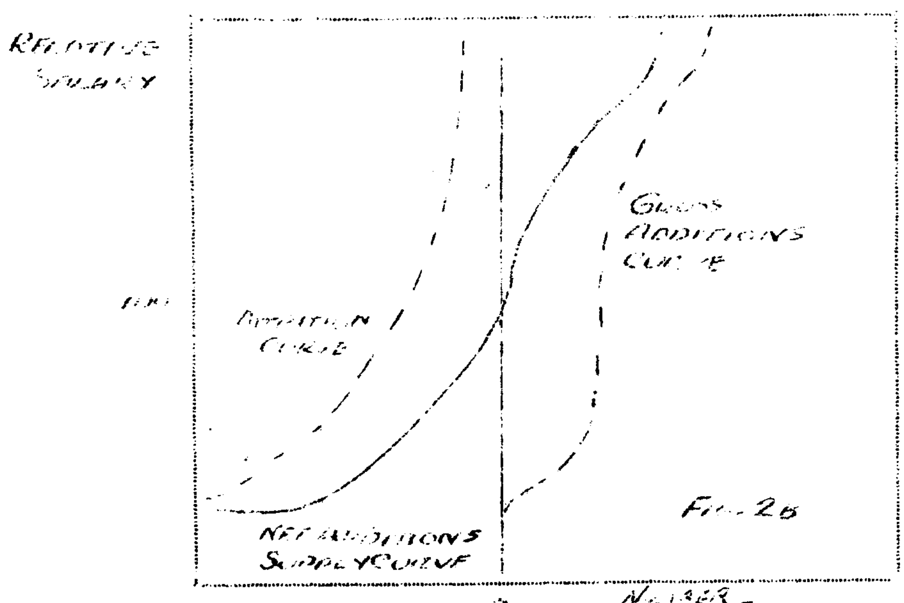
[2/] By "inelastic" we mean $\frac{\partial \log q}{\partial \log p} < 1$ in conventional economic terminology in which q is quantity and p is price. This means approximately that a one percent increase in price would lead to a less than one percent increase in quantity. "Elastic" means $\frac{\partial \log q}{\partial \log p} > 1$, which means approximately that a one percent increase in price leads to more than a one percent increase in quantity.



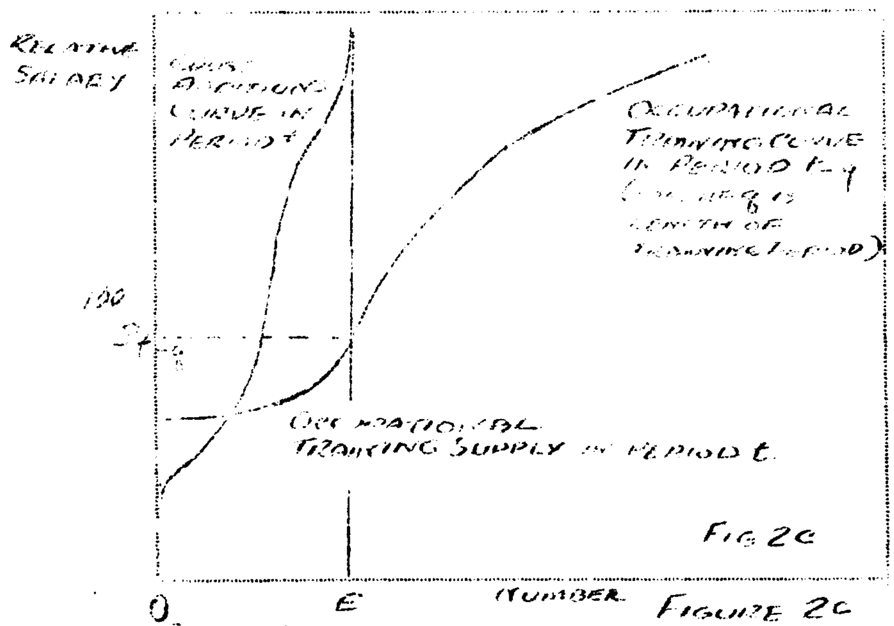
SUPPLY CURVE FIGURE 1



SHORT-RUN SUPPLY CURVE FIGURE 2A



NET ADDITIONS SUPPLY CURVE FIGURE 2B



GROSS ADDITIONS CURVE FIGURE 2C

supply "E" (vertical line) in period t is the result of salary S_{t-q} in period t-q. Regardless of the salary, gross additions cannot exceed E in period t.

For the hypothetical occupational labor market that we have described we have drawn the short-run supply curve and the net additions supply curves as highly elastic at a low relative salary, and highly inelastic at a high relative salary. The explanation of this lies in the shape of the attrition curves and the gross additions curve. The attrition curve has been drawn to increase steadily in slope from highly elastic for low relative salaries, resulting from postulated very high outward movement to high inelasticity for high relative salaries indicating a reduction of outward movement to a minimum. If outward movement in earlier periods has been high enough, it is possible to have negative attrition in that persons reentering the occupation outnumber those leaving. The gross additions curve has been drawn in a flattened "S" shape with high inelasticity vertical sections at both ends. The flattened portion of the "S" represents the commitment of people who have chosen and trained for the occupation in a fairly wide range of relative salaries. At a very high relative salary supply is more elastic, but is eventually abruptly twisted into complete inelasticity by the absolute maximum limit resulting from the earlier occupational training supply decision. At a very low relative salary supply is elastic, trailing off into an inelastic section as a few diehards enter the occupation regardless of salary. The occupational training curve is shown as a flattened "S." At low relative salaries the curve is elastic at a minimum salary, indicating there is a salary below which no one will enter training for the occupation. Supply is less elastic above this minimum, and at very high salaries is highly elastic.

The hypothetical market we have described has obviously been idealized. Except for the large decreases in numbers offering at low salaries and the ultimate vertical sections of the supply curves and elastic sections of the training curves none of the curvatures conditions that were postulated are essential to the following argument.

The relationship we have described between the occupational training curve and the short-run supply curve is most rigid for those occupations in which there is a regular and fixed period of training and prohibition of entry except through training. These conditions apply to medicine and dentistry quite well, but apply far less well to engineering. While it is commonly thought that "engineering supply" is largely graduate engineers, it will be shown below that nongraduates play a large and important role in engineering work. Thus it is deceptive to concentrate exclusively on engineering graduates in discussing engineering supply. There are several possible ways of treating nongraduate engineers. They may be treated as (a) a separate substitute factor of production, (b) engineers of slightly different quality, or (c) as engineers who have obtained their training in a different way. In the section in which we analyze engineering enrollment and degrees we will be treating graduate engineers as a separate factor, in discussing income, the average quality of nongraduates will seem low, but in general discussions of engineering supply it will be well to think of nongraduate engineers as engineers that have obtained their training in a different way.

The available data do not permit the estimation of the curves we have discussed above. Changes in occupational mobility, numbers of young people and other variables does not permit us to isolate the relationship between relative salaries and the number of people entering the occupation. Nevertheless, the categories represented by the curves are useful. It seems that attribtion is unlikely to very elastic with respect to small changes in relative salaries, so that the gross additions curve is likely to differ by approximately an additive constant from the supply curve. Data about the occupational training curve is very limited for scientists. Movements in degrees, however, may allow some inferences about movements in enrollment four years earlier.

The next two sections of this paper are devoted to the presentation of data concerning engineering enrollments, degrees, and starting salaries. The analysis is then resumed in the fourth section.

II. Trends in Undergraduate Engineering Enrollments and Engineering and Science Bachelors Degrees

In analyzing the supply of engineers and scientists, we shall initially restrict outselves to the formal educational process by which a majority of engineers and scientists prepare themselves to work in engineering and science jobs. We further limit ourselves to male engineering and science graduates and undergraduate education. The restriction to men is of little consequence, since over 99 percent of the enrollments and graduates in engineering are men, and a very large majority of graduates in mathematics and physical science are men. We shall therefore discuss male enrollments and degrees in engineering and total enrollments and degrees as if they were identical, while we shall use male degrees for science graduates almost exclusively, since the women who gain degrees do not have a substanital influence on the supply of scientists. The role of women in science supply and the special problems of graduate science and engineering and enrollment will be discussed in detail in separate papers in the future.

The number of male high school graduates has increased steadily since 1945 except for a very slight decrease from 1950 to 1951 (Table 1). The dip was perhaps the result of the drop in the number of births from 2,440,000 in 1932

Table 1

Freshman Enrollment in Engineering, Male
First-Time College Enrollment, and Male
High School Graduates, 1945-196

Academic Year	Male High School Graduates (Spring)	Male First Time College Enrollments (Fall): Number	Male First Time College Enrollments (Fall): As Percent Of Male H.S. Graduates In Previous Year d/	Freshman Engineering Enrollments: Number	Freshman Engineering Enrollments: As Percent of H.S. Graduates (Previous Year) e/	Freshman Engineering Enrollments: As Percent of 1st Time Enrollment
1945-46	466,926	--	--	32,455	--	--
1946-47	514,895a/	499,532	107.0	80,703	17.3	16.2
1947-48	562,863	399,972	77.7	57,507	11.2	14.4
1948-49	566,782a/	369,924	65.7	47,672	8.5	12.9
1949-50	570,700	357,265	63.0	41,863	7.4	11.7
1950-51	562,500	319,733	56.0	34,299	6.0	10.7
1951-52	569,200	280,277	49.8	39,571	7.0	14.1
1952-53	572,800b/		56.9	51,631	9.1	16.0
1953-54	612,500	344,844	60.2	60,478	10.6	17.5
1954-55	645,300b/	386,549	63.1	65,505	10.7	16.8
1955-56	679,500	418,363	64.8	72,825	11.3	17.4
1956-57	692,200b/	446,114	65.7	77,738	11.4	17.4
1957-58	725,500	445,324	64.3	78,757	11.4	17.7
1958-59	811,750b/	468,625	64.6	70,029	9.7	14.9
1959-60	898,000	490,622	60.4	67,704	8.3	13.8
1960-61	919,000b/	542,774	60.4	67,556	7.5	12.4
1961-62	940,000	595,794	64.8	67,575	7.4	11.3
1962-63	959,622c/	601,993	64.1	64,707	6.9	10.2
1963-64	--	608,562	63.4	65,740	6.9	10.8

a. Estimated by averaging preceding and following years.
b. Estimated by averaging U.S. Office of Education.
c. Estimated from data for publich high school graduates in 1963.
d. Enrollment in fall of year as percent of graduates in spring of preceding year.
e. Enrollment in fall of year as percent of graduates in spring of preceding year.

Sources: U. S. Office of Education: Digest of Educational Statistics, 1963.

to 2,307,000 in 1933. Despite the fairly steady growth in the number of male high school graduates, the number of male first time college enrollments has shown a different pattern. The number of male first time college enrollments decreased from .5 million in 1946-47 to .3 million in 1951-52, and thereafter grew steadily to .6 million in 1962-63. The ratio of male first time college enrollments to male highschool graduates has tended to be above 60 percent in years after wars when veterans were enrolling in large numbers and have been low in other years (except for the last few years in which there appears to have been a steady increase in the proportion of highschool graduates entering college despite the small numbers of veterans entering college.)

Freshman engineering enrollment reached its peak in 1946-47 with 81,000 freshman enrollments. This was 16 percent of male first-time college enrollment. As veteran enrollment declined, the proportion of first-time enrollment in engineering also declined, but the proportion rose to a plateau of 16 to 18 percent during the period from 1952 to 1957. The proportion of male first-time enrollment in engineering declined steadily after 1957-58 to 10 percent in 1961-62.

Engineering enrollments in the upper years and degrees generally have reflected movements of freshman enrollments in earlier years. There were very heavy new enrollments in second, third, and fourth year students in 1946 as veterans returned to college with advanced standing (Table 2). The number of graduates generally lagged three academic years behind the number of freshman enrollments. Of the 81,000 freshman in 1946, there were 72,000 sophomores in 1947, 60,000 juniors in 1948, 56,000 seniors in 1949, and 53,000 graduates in 1949-50. Thus only 65 percent of the freshman entering in 1946 graduated as engineers in four years. The proportion of first-year enrollments in engineering graduating three academic years later has been lower than this in all

Table 2

Engineering Undergraduate Retention Rates

Year	(1) 2nd year enrollment as percent enrollment	(2) 3rd year as percent of 2nd year enrollment	(3) 4th year as percent of 3rd year enrollment	(4) Degrees as percent of 4th year fall enrollment	(5) Degrees as percent of 1st year 3 years earlier
1946-47	155.3	272.3	307.5	180.9	
1947-48	88.7	95.7	105.7	90.9	--
1948-49	92.1	83.7	94.7	84.8	
1949-50	83.0	87.0	92.9	98.9	65.3
1950-51	73.8	87.0	90.5	94.7	72.8
1951-52	78.0	89.1	89.2	100.5	63.7
1952-53	76.4	93.5	94.3	98.6	57.7
1953-54	71.8	88.7	96.6	93.1	64.8
1954-55	72.9	87.3	95.4	92.0	57.1
1955-56	77.6	89.3	96.8	88.4	51.0
1956-57	76.6	87.7	95.4	84.0	51.6
1957-58	72.7	86.8	95.5	83.1	53.9
1958-59	67.9	83.6	91.8	83.0	52.4
1959-60	68.5	81.8	91.5	85.8	48.6
1960-61	69.0	83.6	94.6	87.5	51.2
1961-62	72.1	83.8	97.9	86.7	51.3
1962-63	73.1	85.6	97.8	88.4	49.5
1963-64	74.0	84.0	98.3	87.4	--

Source: U. S. Department of Health, Education and Welfare, Office of Education, "Engineering Enrollment and Degrees 1961", Table 10, p. 10. "Advance Report on Engineering Degrees (1961-62), and enrollments (Fall, 1962)". "Advance Report on Engineering Degrees (1962-63) and Enrollments (Fall, 1963)." Journal of Engineering Education, "Enrollments In Engineering Colleges" for years 48-49.

years but 1950-51. The very high proportion in 1950-51 no doubt reflects the delayed graduation of the very large entering class of 1946-47, four academic years earlier. The decline of the ratio of graduates to freshman three years earlier does not mean that all these students are dropping out. Rather it indicates transfer out of engineering to other fields. The veterans that made up large fractions of the freshmen engineering enrollments in the early postwar years apparently had somewhat more settled choices of specialty than freshmen engineers in later years.

Engineering degrees reached a maximum of 53,000 in 1949-50 and reached a second relative maximum of 38,000 in 1958-59 and thereafter declined (table 3). The proportion of all men's first degrees in engineering was highest in 1947-48 with 17 percent and thereafter declined to 12 percent in 1953-54. A second peak of 15 percent in 1958-59 was followed by another decline despite the stability of the percent of first-time enrollments entering engineering for the corresponding period three years earlier. Thus the rate at which freshman engineers graduated three years later declined for freshman for freshman entering after 1955-56.

Movements in physical science and mathematics degrees were somewhat different in detail from the movements of engineering degrees. While the broad movements in numbers reflected the decline of engineering enrollments, physical science degrees as a percent of all men's first degrees never rose above 4.9 percent nor fell below 4.4 percent during the period since the end of World War II (Table 3). The distribution of degrees among physical science specialties changed somewhat over the period, with geology growing from one tenth to one fifth and then declining to one tenth of physical science first degrees, while chemistry declined from three fifths to one half, and physics grew from slightly

Table 3

Bachelors and First Professional Degrees in
Engineering, Physical Science, and Mathematics for Men 1948-1962

	Number				Percent of all Men's Degrees				
	Bachelors and 1st Professional Degrees Total	Engineering	Mathematics[a]	Physical Science[b]	Total	Engineers	Mathematics[a]	Physical Science[b]	Mathematics, Physical Science, and Engineering
1947-48	176,146	30,905	2,619	8,710	100.0	17.5	1.5	4.9	24.0
1948-49	264,222	45,446	3,513	12,185	100.0	17.2	1.3	4.6	23.1
1949-50	329,819	52,071	4,946	15,850	100.0	15.8	1.5	4.8	22.1
1950-51	279,343	41,386	4,311	12,773	100.0	14.8	1.5	4.6	20.9
1951-52	227,029	30,489	3,389	10,160	100.0	13.4	1.5	4.5	19.4
1952-53	200,820	24,152	3,122	8,661	100.0				
1953-54	187,500	22,264	2,722	8,201	100.0	11.9	1.5	4.4	17.7
1954-55	183,602	22,527	2,724	8,426	100.0	12.3	1.5	4.6	18.3
1955-56	199,571	26,236	3,097	9,318	100.0	13.1	1.6	4.7	19.4
1956-57	222,738	31,130	3,826	10,401	100.0	14.0	1.7	4.7	20.4
1957-58	242,948	35,223	4,953	11,438	100.0	14.5	2.0	4.7	21.3
1958-59	254,868	38,013	6,504	12,345	100.0	14.9	2.6	4.8	22.3
1959-60	255,504	37,663	8,312	12,537	100.0	14.7	3.3	4.9	22.9
1960-61	255,900	35,732	9,483	11,995	100.0	14.0	3.7	4.7	22.4
1961-62	262,015	34,610	10,356	12,417	100.0	13.2	4.0	4.7	21.9

a. Does not include statistics and actuarial science.

b. Includes astronomy, chemistry, metallurgy, physics, and geology only. Does not include physical sciences, general; meteorology; geophysics; oceanography; other earth sciences; or other physical sciences.

Source: U. S. Office of Education, "Earned Degrees Conferred," various years.

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more than one-fifth, to somewhat less than two-fifths of physical science degrees (Table 4).

The number of men's degrees in mathematics fluctuated in step with the number of men's first degrees, leaving mathematics degrees as a percentage of all men's first degrees constant at 1.5 percent until 1954-55 (Table 3). Starting the next year, the number rose sharply and steadily, more than doubling the number graduated in the peak veteran year of 1950-51. Mathematics degrees as a percentage of men's first degrees reached four percent. Most of the remarkable growth of mathematics degrees has occurred during a period when engineering degrees were decreasing as a proportion of all men's degrees.

III. Starting Salaries of Engineers and Scientists

Starting salaries of engineers, scientists, and all college graduates have increased steadily since the end of the World War II. It is not possible to provide detailed data on the movements of these groups. Data over a long period are available in the results of the Endicott survey and the American Chemical Society survey. The Endicott survey is conducted annually by Dr. Frank Endicott of Northwestern University. The sample is drawn from large employers that recruit on college campuses. From this survey we obtain a series for engineers and for general business trainees which we shall use to represent movements of nontechnical college graduates (Table 5). The American Chemical Society survey is drawn from reports of accredited college departments of chemistry. We shall use this chemist's series to represent movements of scientists' salaries.

Over the period 1952-62, for which comporable data are available, engineering salaries increased by 82 percent, chemists' salaries by 62 percent, and general business trainees' salaries by 72 percent. Engineers' starting salaries

Table 4

Men's Bachelor's and First Professional Degrees in Physical Science, Selected Specialties, 1947-1962

							Percent of Total					
	Total[a]	Astronomy	Chemistry	Metallurgy	Physics	Geology	Total	Astronomy	Chemistry	Metallurgy	Physics	Geology
1947-48	8,710	15	5,361	335	1,962	1,037	100.0	0.2	61.5	3.8	22.5	11.9
1948-49	12,185	15	7,429	356	2,645	1,740	100.0	0.1	61.0	2.9	21.7	14.3
1949-50	15,850	26	9,134	469	3,287	2,934	100.0	0.2	57.6	3.0	20.7	18.5
1950-51	12,773	23	7,036	400	2,671	2,643	100.0	0.2	55.1	3.1	20.9	20.7
1951-52	10,160	16	5,717	260	2,141	2,026	100.0	0.2	56.3	2.6	21.1	19.9
1952-53	8,661											
1953-54	8,201	11	4,727	33	1,877	1,553	100.0	0.1	57.6	0.4	22.9	18.9
1954-55	8,426	10	4,781	12	1,920	1,703	100.0	0.1	56.7	0.1	22.8	20.2
1955-56	9,318	14	4,996	15	2,233	2,060	100.0	0.2	53.6	0.2	24.0	22.1
1956-57	10,401	14	5,297	8	2,623	2,459	100.0	0.1	50.9	0.1	25.2	23.6
1957-58	11,488	17	5,705	40	3,042	2,684	100.0	0.1	49.7	0.3	26.5	23.4
1958-59	12,345	24	5,895	31	3,668	2,725	100.0	0.2	47.8	0.3	29.7	22.1
1959-60	12,587	31	6,005	32	4,166	2,353	100.0	0.2	47.7	0.3	23.1	18.7
1960-61	11,995	21	6,096	33	4,092	1,753	100.0	0.2	50.8	0.3	34.1	14.6
1961-62	12,417	38	6,371	49	4,624	1,335	100.0	0.3	51.3	0.4	37.2	10.8

a. Includes listed specialties only.

Source: U.S. Office of Education, "Earned Degrees Conferred" various years.

Table 5
Starting Salaries of Graduates in Engineering, Chemistry, and General Business Trainees, 1948-1964

	Engineers' Monthly Salary	(Endicott) As Percent of General Business Trainees	Chemists (ACS) Monthly Salary	Chemists (ACS) As Percent of General Business Trainees	General Business Trainees (Endicott)
1948	250[a]	113.1	--	--	221[a]
1949	261[a]	110.6	--	--	236[a]
1950	260[a]	111.1	--	--	234[a]
1951	270[a]	112.0	--	--	241[a]
1952	305[a]	112.5	325	119.9	271[a]
1953	325[a]	111.3	352	120.5	292[a]
1954	355[b]	110.2	370	114.9	322[b]
1955	371[b]	110.1	na		337[b]
1956	415[b]	114.3	407	112.1	363[b]
1957	454[b]	115.5	440	112.0	393[b]
1958	472[b]	116.0	440	108.1	407[b]
1959	489[b]	119.0	450	109.5	411[b]
1960	510[b]	119.2	490	114.5	428[b]
1961	529[b]	121.6	500	114.9	435[b]
1962	554[b]	118.9	525	112.7	466[b]
1963	580[b]	120.3	--	--	482[b]
1964	596[a]	120.9	--	--	493[a]

a. Proposal by companies responding to survey.
b. Actually paid in year by companies responding in next year's survey.

Source: Endicott data from annual surveys furnished by Dr. Frank Endicott, Northwestern University. ACS data from annual surveys published in Chemical and Engineering News.

are not only higher than the starting salaries of general business trainees, but the salary ratio of engineers to general business trainees has increased. Chemists starting salaries have remained about $60 higher than the starting salaries of general business trainees, so that the salary ratio has fallen.

IV. Analysis of Changes in Enrollments and Degrees

The data presented in the preceding sections led to these important findings:

(1) The proportion of male college entrants that enter engineering has declined in recent years despite the increase in the starting salaries of engineers both absolutely and as a percent of the starting salaries of general business trainees.

(2) The proportion of male first degrees that are in engineering has declined, in recent years, despite the stability of the percentage of male college entrants in engineering during the corresponding period.

(3) The proportion of male first degrees in physical science has remained constant despite a decline in the starting salaries of scientists (actually chemists) relative to the salaries of general business trainees and of engineers.

(4) The proportion of men's first degrees in mathematics has increased steadily in recent years. There is no evidence that mathematics salaries have increased relative to other salaries over the period.

These findings are in conflict with the presumed shapes of the supply curves presented in the first section. An occupational training supply curve of engineers fitted to post-Korean war data would apparently be negatively sloped. The gross additions supply curve of engineers would also be negatively sloped since the retention rate for engineering students fell during a period when the relative salaries of engineers increased. Although detailed information on science enrollments and degrees is lacking, the lack of movement in the proportion of degrees can reflect either inelasticity of the occupational training supply curve and the gross additions supply curve or the small amplitude of fluctuations in the relative salaries of physical scientists. The remarkable increase in the proportion of graduates that are in mathematics far outstrips any reasonable degree of elasticity of the occupational training supply or gross additions supply curve, especially in view of the evidence that the salaries of mathematics majors have probably not increased relative to salaries in most other occupations of college graduates during the period of rapid growth.

The apparent perversity of the supply curves of engineers and scientists is made more significant by the fact that both engineering and science starting salaries are somewhat higher than starting salaries of most other occupations. The higher level of starting salaries coupled with the increasing relative level of salaries in engineering should have provided an increasing economic incentive for students to enter engineering training. If it did so, then the economic incentive was offset by changes in other influences on occupational choice.

Occupational choice. In discussing occupational choice we wish to limit ourselves to the factors that affect the shape of the occupational training supply curves (OTS curves) for engineers, scientists, and mathematicians and shifts in the curves. It seems clear that these occupations are closely related. A large shift in the physical science OTS curve is unlikely to leave the OTS curves for mathematicians and engineers unaffected. All of these educational specialties require intellectual traits commonly labeled quantitative reasoning and mathematical ability. Engineers tend to be more application minded, while mathematicians tend to be more abstract. But the differences in the characteristics of the occupations are perhaps less important than the similarities in educational specialties. Physical science and engineering both place heavy emphasis on laboratory work, while physics, engineering, and mathematics all require some concentration and success in the study of mathematics.

Students who lack or believe they lack mathematical ability are barred from these educational specialties. Moreover, many students dislike or fear mathematics and science. Physical science and engineering also require considerably more class time than most other college majors. Adequate mathematical preparation for these majors must generally be begun in high schools, where college algebra, trigonometry, and where possible analytic geometry or an introduction to the calculus should be taken. If they are not taken, there is additional inconvenience in entering the major. All of these factors tend to separate students prepared for engineering, physical science, and mathematics from the rest of the college entrants. Even substantial premiums in salaries for occupations in this group are unlikely to induce many of the students who lack mathematical ability and a taste for its exercise to enter training for these occupations. The importance of the requirement of early preparation for scientific and engineering training is widely recognized. It is also clear that the highschool student usually is not required to take the advanced mathematics and science course necessary for normal progress in science. This need for a preliminary decision before college is important in view of the lateness of most students' occupational choice decisions. Ginzburg and his associates (8, p. 190) suggest that most realistic occupational choices are made between ages 16 and 18, and that choices are crystallized in the majority of cases between the ages 19 and 21. For engineering students, of course, this crystallization often results in a decision to transfer out of engineering. But it is usually difficult and inconvenient for anyone who has not previously begun engineering training to decide to become an engineer. The decision not to study engineering (and to a lesser degree physical science and mathematics) is practically irreversible.

Aside from economic expectations and educational requirements, the factors that affect the occupational training supply are complex and difficult to pin down. Parents, teachers, friends, and relatives all play an important role in determining the range of choices open to the child. It seems likely that the informal "counselling effects" will change only slowly over time. The direction of their movement seems also likely to reflect changes in economic conditions in the occupation that could be represented by a set of lagged relative income variables. The influence of informed vocational counsellors should also reflect economic conditions with somewhat less lag than uninformed community opinion.

While it may appear somewhat surprising that counselling should have little independent effect on occupational choice, it need only be noted that occupational prestige, job security, working conditions, and other components of psychic income are usually highly correlated with earnings in a highly commercialized market economy such as the United States, so that there are relatively few occupations which rank high in earnings that do not also rank high in other components which might influence counsellors.

These non-earning characteristics of occupations cannot be evaluated because of lack of data for most jobs. It is possible, however, to draw some conclusions about changes in the "counsellor effect" and in occupational prestige. These are discussed below.

It is necessary to discuss briefly the measures of earnings that might be chosen to represent the economic characteristics of an occupation. It should be clear, first of all, that no one measure is a complete representation of relative economic advantages for a group of people. Since persons differ in their rates of time preference, one man might look only at earnings in the first year or so, while another would consider present value of the lifetime earnings of an occupation, discounted at a low rate of interest. Only if subjective rates of time discount are very high, will starting salaries necessarily be highly correlated with present values of occupational earnings. We have chosen to discuss earnings in occupations in terms of starting salaries largely from necessity, and not from the belief that these are the predominant economic variables that influence decisions. A second consideration is the range and variance of earnings in an occupation. Persons with considerable confidence in their superiority and luck may pay more attention to the top percentiles of earnings than to measures of central tendency. A third major consideration is the interrelation of occupations. The present value of lifetime earnings in an occupation computed in the conventional manner includes only the earnings of persons that are in the occupation at a given point in time. In many entry occupations high earnings are gained only by passing out of the occupation. Thus, many newspaper reporters become public relations men and many engineers become business executives. In contrast, occupations such as physician are usually lifetime occupations. In judging the economic value of one occupation it is necessary to take account of the other occupations to which the first provides a port of entry.

<u>Effect of vocational counselling</u>. The sharp decline in the proportion of freshmen enrolling in engineering that followed the announcement of the Bureau of Labor Statistics in 1949 (3) of an impending glut of engineers has led to much criticism of the Bureau. Hansen writes (10, p.41), for instance:

> ...a "surplus" of engineers was officially predicted unless younger men could be persuaded to pursue other types of careers. A fairly quick reaction to this occured, with the result that in the early fifties engineering enrollments and graduates began to decline as a proportion of total male enrollments and graduates. This effect was compounded because of the smallness of the school-going population resulting from the birthrate decline of the thirties.

Actually, as we have shown above, the number of male highschool graduates decreased in only one year, so that the birthrate decline had no important effect in reducing the number of entering freshmen. The decline in enrollments was predominately the result of the decline in veterans enrollment (this is shown below.) The question of whether or not the prediction of the glut in 1949 and the relatively difficult problems which engineering graduates in the class of 1949 had in finding jobs were major causes of the decline in enrollment proportions in the early fifties can have no conclusive answer. If the advice of counsellors was a major cause of the reduction in percentage of male freshmen choosing engineering in the early fifties it was effective for only one year, in the fall of 1950 when on 10.7 percent of male college freshmen chose engineering. By 1953 the percentage had climbed to a record level of 17.5 percent that was maintained at high levels until the new record year of 1957 when 17.7 percent of male freshmen chose engineering. The climb from 10.7 percent in 1950 to 17.5 percent in 1953 was during a period of very high excess demand which was represented by a high level of job vacancies (see Folk (7), p. 12).

This enormous increase in freshman enrollments occurred during a period when engineering starting salaries had not risen relative to general business trainees salaries ('able). In short, freshmen responded to engineering job market in which improvement was represented by unfilled vacancies rather than by salary increases.

It is worth noting that engineering freshman enrollments as a percent of all male freshmen enrollments were 11.7 percent in 1949 and 12.9 percent in 1948. Thus it seems very unlikely that the BLS announcement in 1949 had a noticeable effect. In 1956 and 1957 engineering job vacancies were at their record level in number (but probably not as a percent of engineering jobs), relative engineering salaries were rising, and the "shortage of engineers" received constant attention from the press and from high school counselors. Nevertheless, the proportion of male freshmen entering engineering began a decline that reached a record post-war low of 10.2 percent in 1962, which was year of temporarily high engineering job vacancies. In 1963, the proportion of freshmen enrolling in engineering increased very slightly. The marked decline in engineering freshmen as a percent of all male freshmen occurred during a period when starting salaries for engineers were rising relative to other occupations, counselors were stressing the advantages of engineering, but job vacancies were falling or low.

In these movements it is impossible to identify an independent effect that can be traced to counseling. The "glut forecast" in 1949 had the effect of reducing freshmen engineering enrollments as a percent of all male freshmen enrollments by at most one percentage point. The decline in the freshman engineering percentage from 17.7 to 10.2 occurred during a period when the counselling effect was very much in the direction of encouraging engineering careers.

The relatively slight effect of counselors that is suggested by these data is supported by two surveys of engineering students which suggest that counselors were influential in the career decision in about 5 percent of the cases (Anger (2), and (1).

It is clear also that relative starting salaries have not noticeable relationship with freshman engineering percentage. The best explanatory variable (and it is none too good) is the number of engineering job vacancies. But the level of job vacancies is not an explanation of the low level of engineers as a percent of all male freshmen in 1962.

Prestige. Prestige has been defined at the "...approval, respect, admiration, or deference a person or group is able to command by virtue of his or its imputed qualities or performance." (Johnson (11), cited in Gusfield (9)). Numerous studies have been made of the relative prestige of occupations (Table 6). We have chosen to examine a number of these for evidence that would suggest the prestige of engineers and scientists relative to other occupations that college graduates commonly enter. Although it has been suggested (by Reiss. (16)) that prestige has little influence on occupational choice, it is desirable whether or not the relative prestige of engineers and scientists has changed and could thereby be an independent factor in occupational choice. It is necessary first to discuss briefly some of the problems which are common to studies of relative prestige. First, prestige is seldom defined in detail. Sometimes the respondents are asked to rank professions in the order that they look up to them, or in order of social status, social contribution, general esteem, or social distance. Obviously the wording of the question will have some bearing on the results (see Gusfield (9)). The reassurance that Counts provides in his ground-breaking

Table 6

Prestige Rankings of Occupations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
				1929 Anderson				1934-35 (Coutu)								
	1925[a] Counts	1926 Anderson	1928 Nietz	"contribution"	"prestige"	1932 Nietz	1934 Nietz	Medi-cine	Eng'g	Law	1938 Asch	1940 Smith	1946 Dege	1946 NORC	1956 Rose	1963 Gusfield
Banker	1	4	2	4	1	2	1	-	-	-	-	1	2.5	4	-	4
College Professor	2	3	1	3	5	3	2	3	3	3	2[g]	-	-	2.5	-	-
Physician	3	2	4	2	2	1	3	1	2	2	1	2	1	1	1	-
Clergyman	4	1	3	1	3	6	5	7	7	7	-	5	-	5	-	-
Lawyer	5	6	5	6	4	5	4	5	6	1	4	3	2.5	6	2	2
Engineer	6[b]	5	6[b]	7	6	4	6	4[c]	1	8[e]	3	-	4[b]	7[b]	4	3[b]
School Teacher	7[c]	7	7[d]	5	8	7[d]	7[d]	9	9	9	-	6	5[f]	9	3[f]	5
Factory Manager	8	8	8	8	7	8	8	-	-	-	-	-	-	-	-	-
Insurance Agent	9	9	9	9	9	9	9	-	-	-	-	-	6	10	5	-
Natural Scientitst	-	-	-	-	-	-	-	2	4	4	-	-	-	2.5	-	1
Accountant	-	-	-	-	-	-	-	8	8	6	5	-	-	8	-	-
Architect	-	-	-	-	-	-	-	6	5	5	-	4	-	6	-	-
Number of Respondents	450	609	346	673	673	332	1,622	202	343	142	96	345	475	-	68	337
Type of Student Respondents	high school	college	high school	college	college	high school	high school		professional students		college,		college, high school	Natl. Sample		
Location	Minn. Conn.	N.C.	Ohio W. Va. N.C.	N.C.	N.C.	Ohio, W. Va., Penn.			Wisc.		N.Y.		Minn.			

Table 6

Prestige Rankings of Occupations (continued)

Source: (1) Counts, George S. "Social Status of Occupations," School Review, 1925, pp. 16-27.
(2) Anderson, W. A. "Occupational Attitudes and Choices of a Group of College Men: Part I," Social Forces, 1927, pp. 278-83.
(3),(6),(7) Nietz, John A. "The Depression and the Social Status of Occupations," Elementary School Journal, 1935, pp. 454-61.
(4),(5) Anderson, W. A. "Occupational Attitudes of College Men," Journal of Social Psychology, 1934, pp. 435-66.
(8) (10) Coutu, W., "The Relative Prestige of Twenty Professions as Judged by Three Groups of Professional Students," Social Forces, May, 1936, p. 522.
(11) Asch, Solomon E., Helen Block, and Max Hertzman, "Studies in the Principles of Judgements and Attitudes-I" Journal of Psychology, 1938, p. 219.
(12) Smith, Mapheus, "An Empirical Scale of Prestige Status of Occupations," American Sociological Review, April, 1943.
(13) Deeg, Maethel E. and Donald G. Paterson, "Changes in Social Status of Occupations," Occupations, January, 1947, pp. 205-208.
(14) National Opinion Research Center, "National Opinion on Occupations", March 1946, summarized in Wilson, L. and W. L. Kolb, Sociological Analysis, New York: Harcourt, Brace, and Co., 1949.
(15) Rose, A. W. and M.C. Wall, "Social Factors in the Prestige Rankings of Occupations," Personnel and Guidance Journal, March, 1957, pp. 420-423.
(16) Gusfield, Joseph R., "The Meanings of Occupational Prestige: A Reconsideration of the NORC Scale," American Sociological Review, April, 1963, p. 265.

a. Counts did not report the date of his study.
b. Civil engineer.
c. High school teacher, Elementary teacher ranked below factory manager and above insurance agent.
d. High school teacher, Elementary school teacher ranks below High School, but above next occupation.
e. Electrical engineer.
f. Elementary school teacher.
g. "Teaching".

paper (4) that there is little variation in the rank ordering by high school seniors in different areas and classes, was shaken somewhat by Coutu's hardly surprising finding (5) that professional students tend to rank the profession they had chosen first in prestige.

Accepting these limitations of the data, we can see that ...engineering ranks low among the college trained occupations. Bankers and physicians usually top the prestige lists. Bankers actually had higher prestige after the monetary disaster of 1929-33, ranking first in both 1934 and 1940. Perhaps this can be traced to the belief that they had money when few others did. Physicians show high rankings in recent years, after although not necessarily because of the rapid rise in earnings that followed World War II. College professors show surprisingly high rankings. That the samples are most often drawn from impressionable youth in high school and college may explain the high rank of professors although the NORC studies also give them high rank. Clergymen have top rank only with Anderson's students at North Carolina State College in Dixie's bible belt, and their relative rank appears to have fallen off. Lawyers usually rank immediately above or below clergymen. Engineers seldom rank above lawyers but with one exception rank above school teachers. Natural scientists may very high prestige in every survey in which they appear.

That scientists have higher prestige than engineers does not seem unreasonable. The term "scientist" probably connotes for many people a Ph.D. who has people helping him, while "engineer" conduces a much less commanding picture of individual prominence. Of course if two similar jobs were compared, such as "professor of engineering" and "professor physics" the scientist might still have higher prestige, perhaps because of the supposedly great purity of his work.

The purpose of our inquiry in to prestige, however, was to discover whether or not engineers and scientists had experienced a change in relative prestige in recent years. We have found no evidence that a change in prestige has occurred. Engineers have remained just below the professions that require post-graduate work in prestige, while science has been among the most prestigious two or three occupations.

Growing attractiveness of mathematics. The marked increase in degrees in mathematics as a percentage of all male degrees from an almost constant 1.5 percent before 1955 to 4.0 percent in 1962 poses an important problem for analysis. The increase occurred during a period when physical science degrees were a constant percentage of all men's degrees. Over part of the period, engineering degrees as a percent of all degrees increased slightly, showing that the increase in the mathematics degree percentage was not a simple case of engineering majors transferring into mathematics. Thus the growth in the mathematics percentage has been largely in addition to stability in the percentage of men's degrees in physical science and engineering. If we consider mathematics, physical science, and engineering percentages in the period since the Korean War. The increase in the mathematics degrees is the only movement in composition of much consequence. Possible explanations are many, but none describe much confidence. They include:

(1) Growth of industrial demand owing the expansion of automatic computing machinery and R&D.

(2) Growth of demand in teaching at secondary and college levels.

(3) Improvement in mathematics teaching in schools.

(4) Growth in transfer from sciences and engineering resulting from the increasingly mathematical nature of these disciplines.

Automatic computing machinery first became important commercially about 1951. The growth of modern computer technology and use has stimulated demand for mathematicians and programmers. Salaries for experienced programmers with advanced degrees in mathematics are often well above $15,000 a year and compare favorably with the earnings of well-trained scientists and engineers. There is no evidence that the starting or average salaries of mathematics majors are exceptionally high. According to the 1960 Census, the 1959 median wage and salary earnings of natural scientists and mathematicians were:

Chemists	$7,094
Geologists and Geophysicists	8,198
Physicists	8,999
Mathematicians	7,721

The growth in demand for mathematics teachers has probably been somewhat greater than the growth in demand for science teachers, but the shortages experienced by schools have been far greater for mathematics teachers because of the rapid expansion of alternatives in industry for persons with training in mathematics. Secondary teaching has declined in importance as an occupation for mathematics majors. The proportion of the total number of persons with mathematics degrees that are certified to teach has decreased from 72 percent in 1949-50 to 51 percent in 1960-61. 3/

The excess demand for teachers in higher education is also considerable. In surveys in 1959-60 and 1960-61 the National Educational Association found that 142 of the 1,085 colleges and universities had vacanices in mathematics, compared to 200 institutions with vacancies in physical science and 81 with vacancies in engineering. 4/

3/ Derived from Office of Education degrees and certification numbers estimated by the National Educational Association in its annual research reports "Teacher Supply and Demand in Public Schools."

4/ National Education Association, "Teacher Supply and Demand in Universities, Colleges and Junior Colleges 1959-60 and 1960-61," Research Report 1961-R12. Washington, D. C.

That improvement of mathematics teaching in the schools might have contributed to an increased percentage of all men's degrees in mathematics may appear to contradict the assertion of a shortage of mathematics teacher given above. One reason for the shortage, of course, is that enrollment in mathematics has increased rapidly, as can be seen in table 7.

The growth of mathematics enrollment in grades 9 to 12 has been particularly rapid in trigonometry (102 percent) and "other mathematics" (292 percent). "Other mathematics" includes college algebra, calculus, and analytic geometry which are particularly important for students planning to enter college mathematics courses.

The improvements in education which have resulted from the National Science Foundation training programs for mathematics teachers and from the introduction of the "new Math" (which has not had its full effect yet) are no doubt considerable, but cannot yet be measured.

The growing importance of mathematics for persons that wish to enter graduate work in science and engineering has been widely recognized. Engineering, physics, and chemistry alike have been increasingly oriented in mathematical directions. In the social sciences mathematics is also increasingly important. In many of the most respected graduate departments of economics, for instance, a mathematics major with a few courses in economics is often preferred to an economics major with a few courses in mathematics. This trend has probably contributed to the observable shift in the major fields choices made by the most able students. This may be seen from studies conducted by the National Merit Scholarship Corporation among Merit scholarship semifinalist.

Table 7

Percentage of Total School Enrollment
Grades 9-12 in Mathematics Subjects

	1948-49	1958-59
Elementary Algebra	19.3	22.6
Intermediate Algebra	6.9	8.2
General Mathematics	12.0	13.1
Plane Geometry	11.1	12.5
Solid Geometry	1.7	1.4
Trigonometry	2.0	2.8
Other Mathematics.	1.7	4.6
All Mathematics	54.8	65.1
Total Enrollment Grades 9-12	5,399,000	7,841,000

Source: Derived from U.S. Department of Health, Education, and Welfare, Office of Education, Bulletin 1961, No. 5, "Offerings and Enrollments in Science and Mathematics in Public High Schools, 1958," cited in Office of Education, Digest of Educational Statistics, 1963 edition, OE-10024-63, table 10, p. 16.

The semifinalists, students that scored in the top 2 percent on the national screening test given in the junior year, provide information about their college major and career choice during their last year in high school. These data are presented in Appendix Tables 1 and 2. Over the period 1958 to 1963, the percentage of this group choosing mathematics as a major increased from 8 to 16 percent. Physics decreased from 19 to 12 percent, and engineering from 30 to 20 percent. Thus mathematics appears to be getting a higher proportion of these able students, while physics and engineering are of decreasing but still major importance. In 1958, 64 percent of the semifinalists chose majors in chemistry, engineering, geology, mathematics, or physics, while in 1963 the percentage had fallen to 54 percent, all of the decrease being accounted for the decline in engineering.

There are so many changes in plans for majors, however, that the decline in the proportions planning to major in a subject may not be of great importance. In a study of National Merit semifinalists and letter of commendation winners of 1957 (most of whom graduated from college in 1961) it was found that 32 percent had planned to major in engineering, but 22 percent finished in engineering, 12 percent had planned to major in physics while 10 finished in physics and 6 percent had planned to major in mathematics while 8 percent finished in mathematics (Table , below). Thus the outflow from science and engineering was quite high among the students that planned to major in these subjects. It seems likely that with the decline in plans to major in science or engineering those that remain may have considerably high commitment to the subject.

Veterans. Proportionately more veterans than nonveterans study engineering. In 1948, when 60 percent of all male students in higher education were veterans, 70 percent of undergraduate engineering students were veterans (Table 8). In 1963, when only 1 percent of all male students were veterans, 1.7 percent of engineering students were veterans. The higher than average propensity of veterans to choose engineering as a college major may also be seen in the percentage of veterans enrolled in engineering. Since 1948, this percentage has ranged between 12.2 and 16.6 percent, while the corresponding percentage for nonveterans has ranged between 8.3 and 12.5 percent.

The percentage of veterans and the percentage of nonveterans enrolled in engineering have fluctuated together since 1950. The similar movements of the engineering enrollment percentages of veterans and nonveterans suggests that the attitudes toward engineering both of veterans and of nonveterans vary over time. 1957 represents the peak interest of both veterans and nonveterans in engineering. Both percentages have reached very low levels in the last few years.

While data on veteran graduates and first time enrollments in engineering are not available, it is clear that the total enrollment data is well correlated both with first-time enrollments and with graduates. Therefore, when we measure the effect of changes in veteran enrollment in higher education on enrollment in engineering, we have gone a good part of the way toward measuring the effect of changes in the number of veterans on the number of engineering degrees.

To measure the effect of changes in engineering enrollment, consider the interval 1949-1963. Over this interval, the proportion of all students in higher education that were enrolled in undergraduate engineering declined from 11.68 percent to 8.32 percent. This change can be considered to arise from

Table 8

Veterans as a Percent of all Male Students and
Engineering Students as Percent of
Total Male Students in Higher Education
By Veteran Status, 1948-63

	Veterans as Percent of Students in Higher Education		Engineering Students as Percent of Total Male Students		
Year	Total	Engineering (Undergraduate)	Total	Veteran	Nonveteran
1948	59.9	70.0	13.8	15.4	9.9
1949	49.2	59.6	11.7	14.1	9.3
1950	36.3	44.5	10.3	12.6	9.0
1951	28.8	32.3	10.4	11.7	9.9
1952	17.2	22.6	11.3	14.8	10.5
1953	19.7	20.0	12.0	12.2	11.9
1954	23.6	28.1	12.3	14.6	11.6
1955	26.2	31.2	12.7	15.1	11.8
1956	24.8	30.3	13.0	15.9	12.1
1957	22.2	27.5	13.4	16.6	12.5
1958	18.0	24.0	12.2	16.2	11.3
1959	14.5	17.6	11.2	15.8	10.5
1960	7.6	11.7	10.3	16.0	9.9
1961	4.2	6.8	9.6	15.6	9.3
1962	2.1	3.6	8.9	15.0	8.7
1963	1.0	1.7	8.3	13.6	8.3

Source: Appendix Table 3.

two causes: (1) the change in the proportions of veterans and of nonveterans enrolled in engineering (which we will call change in rates); and (2) the change in the proportions of all students in higher education made up of veterans and of nonveterans (which we will call change in composition). Standardizing the 1963 enrollment on the 1949 rates, and the 1949 enrollment at the 1963 rates we obtain:

Percent of Male Enrollment in Engineering

1963 Actual	8.32
1963 (1949 rates constant)	9.34
1963 (1949 composition constant)	10.90
1949 Actual	11.68

The percent enrolled in engineering actually fell from 11.68 percent to 8.32 percent. If the percentage of veterans had remained constant and only the rates had changed, the percent enrolled would have fallen only to 10.90, or less than one percentage point. If rates had remained constant and the percentage of veterans had declined, the percent enrolled in engineering would have fallen to 9.34 percent. This means that 2.34 of the 3.36 percentage point decline (or 70 percent of the decline in the total percentage enrolled in engineering) can be attributed solely to the decrease in the proportion that veterans make up of all enrollment in higher education. 5/

According to this analysis, the decrease in the proportion of veterans has been one potent cause of the decline in engineering enrollments, and consequently of the decline in engineering degrees. If we chose another interval, however, as from 1957 to 1963, we would find:

5/ No mention has been made of the interaction between change in rate and change in composition. In this instance the interaction is -.24.

<u>Percent of Male Enrollment in Engineering</u>

1963 Actual	8.32
1963 (1957 rates constant)	12.55
1963 (1957 composition constant)	9.45
1957 Actual	13.42

Thus from 1957 to 1963, a period in which the percentage of veterans in higher education decreased from 22 percent to 1 percent, the effect of the change in composition only was -.87 percentage points, while the effect of a change in rates only was -3.97. Over this interval the decline in rates was far more important than the change in composition.

Similarly, if we examine the interval 1949-1957, we find:

<u>Percent of Male Enrollment in Engineering</u>

1957 Actual	13.42
1957 (1949 rates constant)	10.37
1957 (1949 composition constant)	14.52
1949 Actual	11.48

Over the interval the engineering enrollment percentage increased from 11.48 to 13.42 percent, but if only the rates had changed, the enrollment percentage would have risen to 14.52 percent. If only the composition had changed, the rate would have fallen to 10.37 percent. Thus, during the interval 1949-1957, the composition shifted against engineering, but this was largely offset by increases in rates. The result was an actual increase in engineering percentage enrollment.

Considering these results it is possible to say that the decline engineering enrollment is largely attributable to (1) the decline in the percentage of veterans; or (2) the decline in percentages of all veterans and of nonveterans that study engineering. The very high variability of the rates among nonveterans suggests that there was no necessary reason that the decline in the proportion of veteran enrollments should have caused a decline in the engineering percentage enrollment. Thus past military service is associated with increases in the probability of a college student choosing engineering, but the probability varies enough that relatively large engineering percentage enrollments can be attained with relatively few veterans. The proportion of nonveteran students enrolled in engineering in 1957 was about the same as the proportion of veteran students enrolled in engineering in 1950.

The relatively high correlation of movements in the percentages of veterans and of nonveterans enrolled in engineering suggests that whatever are the influences on the person that promote or deter enrollment in engineering, they work independently of the veteran status of the person.

V. Occupational Choice After Training

In the previous section we examined occupational training supply, and in this section we examine occupational decisions made after the occupational training has begun. It is obvious that not all persons who choose to train for engineering will work in engineering, or even in occupations for which engineering training is helpful. It is doubtful that engineering and scientific training would actually hurt a person seeking to enter a nonspecialized job and indeed it even may be helpful. Thus, some people may choose engineering and science majors without much intention of entering occupations that require such majors. Especially important for persons with science majors are occupations which do not appear in a science or engineering job classification but which require scientific training such as secondary and college teaching in science and mathematics.

<u>Change in Career Choice During College</u>. We observed above that engineering experienced high attrition in that many of the freshman that chose engineering as freshman did not survive to graduate. Here we wish to deal with the attrition

that takes place during college of those students that remain to graduate. Data on this question is available from a study conducted by the National Opinion Research Center in the Spring of 1961 of a sample of 33,942 June graduates from 135 colleges (Davis, (6)). Most of the seniors graduating in 1961 entered college in 1957. About 15.8 percent of the respondents (60 percent of whom were men) reported engineering as their freshman career. If we assume that all these were men, we can adjust this figure to that about 26 percent of the male seniors had chosen engineering as a freshman career. This percentage is much larger than the 17 percent that enrolled in engineering in 1957, but it may indicate a higher probability of eventual graduation in some subject of freshman engineering students.

Only about one-half of seniors that as freshman had career aspirations in engineering and physical science anticipate these careers as seniors (Table 9). The vast majority of the seniors that as freshman aspiring to engineering careers that change to other careers anticipate careers other than physical science, medicine, or biological science. (Table 10) This suggests that engineering students are not being drawn off into the sciences in college in any important numbers. Seniors that had aspired to physical science careers as freshman had anticipations other than science, medicine, and engineering less frequently than did the seniors with freshman engineering aspirations.

Of those seniors with career anticipations in engineering, 87 percent had aspired to engineering careers as freshmen. No other occupation has such a low rate of recruitment during college. This is no doubt related to the strict four-year curricula that engineering students must follow, but it may also reflect the overselling of engineering as a career that may have occurred as a consequence of the "engineering shortage" of the 1950's.

Table 9

Seniors' Anticipated Careers and Career Aspirations as Freshmen

Career	Percent of seniors who anticipate a career in the occupation that also aspired to the same career as freshmen	Percent of seniors who aspired to the career as freshmen and also anticipate the same career as seniors
Education	84.8	64.5
Business	72.6	49.1
Other Professions	57.3	60.8
Law	56.3	48.7
Engineering	51.3	87.1
Physical Science	50.7	58.1
Humanities	49.7	44.4
Medicine	43.5	76.0
Biological Science	41.6	32.1
Social Science	35.8	23.3

Source: James A. Davis, Great Aspirations: Career Decisions and Education Plans During College, Chicago; National Opinion Research Center, 1963, Table 3, 4, pp. 70-71.

Table 10

Freshmen Career Aspiration
and Senior Anticipated Future Career

Freshmen Career Aspirations	Anticipated Future Career: Eng's	Phys. Sci.	Medi-cine	Biol. Sci.	Other	Total	Number
Engineering	51.3	0.8	1.2	0.7	46.0	100.0	7,398
Physical Science	4.4	50.7	2.7	3.3	39.0	100.1	3,231
Medicine	1.4	4.4	43.5	6.7	44.1	100.1	2,643
Biological Science	2.6	3.4	3.7	41.6	48.6	99.9	833

Anticipated Future Career	Freshmen Career Aspirations: Eng's	Phys-Sci.	Medi-cine	Biol. sci.	Other	Total	Number
Engineering	87.1	3.2	0.8	0.5	8.3	99.9	4,360
Physical Science	20.9	58.1	4.1	1.0	15.9	100.0	2,817
Medicine	5.8	5.8	76.0	2.0	10.3	99.9	1,513
Biological Science	4.7	10.0	16.3	32.1	37.0	100.1	1,081

Source: James A. Davis, Great Aspirations: Career Decisions and Education Plans During College, Chicago: National Opinion Research Center, 1963, Table 3, 4, pp. 70-71.

Choices of Able Students. A study by Nichols (15) drawn from National Merit Scholarship semifinalists and letter of commendation winners (representing slightly more than the top 2% of scores on the preliminary test given in high school junior year) that entered college in 1957 and would normally graduate in 1961 shows large changes in choice of major and career choice over the period (Tables 11 and 12). In majors, the declines of 29 percent in chemistry, 21 percent in physics, and 31 percent in engineering were also large absolutely, since these majors were preferred by 53 percent of the entering students, while mathematics increased by 47 percent. In career choices, scientific researcher decreased by 55 percent and engineer by 53 percent. Together these two careers were preferred by 58 percent of the entering sample. There were large increases in career preferences of 71 percent for business executive, 56 percent for lawyer, and 239 percent for college teacher. In 1961, college teacher was preferred by 17 percent of the sample, more than any other occupation.

The changes in the major field and career choices of the sample over four years of college are very similar to the changes in choices that the different groups of merit scholarship semifinalists have made over approximately the same period (see Appendix Tables 1 and 2).

If the same kind of attrition during college occurs among the much smaller percentages of the 1963 semifinalists choosing science and engineering majors as occurred among the 1957 sample students, there will obviously be a substantial decline in scientific and engineering career choices. A decline similar in magnitude to that occuring in the 1957 sample would still leave engineering with about 11 percent and scientific research with about 16 percent of these very able students. For scientiic researcher at least, this represents a larger proportion than for all seniors. But it is far from

Table 11

Change in Career Choices of Male National Merit Semifinalists and Letter of Commendation Winners During 4 Years of College

Occupation	Percent In 1957	Percent In 1961	Percent Change
Architect	0.91	1.23	35.2
Business Executive	3.74	6.41	71.1
Dentist	0.30	0.35	16.7
Engineer	32.72	15.47	-52.8
Lawyer	5.96	9.33	56.2
Military Officer	2.00	3.24	62.0
Minister	2.75	2.43	-11.0
Physician	9.81	9.51	- 3.3
Proprietor	0.46	0.95	106.5
Scientific Researcher	25.37	11.40	-55.2
Teacher, Primary or Secondary	2.28	2.87	25.4
Teacher, College	4.90	16.63	238.6
Other	8.78	20.20	130.1
Number	3,954	3,975	----
Number Undecided	520	499	----
Total	4.474	4,474	----

Source: Robert C. Nichols, "Career Decisions of Very Able Students," Science, 12 June 1964.

Table 12

Changes in Major Fields of Male National Merit
Semifinalists and Letter of Commendation Winners
During 4 Years of College

Occupations	Percentage 1957	1961	Percent Change
Architecture	3.81	0.88	-71.9
Art	0.33	.45	26.7
Biology	2.32	2.30	- 0.9
Business	3.11	4.35	39.9
Chemistry	8.64	6.14	-28.9
Education	3.00	0.59	-80.3
Engineering	31.61	21.75	-31.2
English	3.33	7.35	120.7
Geology	0.45	0.70	55.6
History	2.25	5.71	153.8
Journalism	0.45	0.56	24.4
Languages	.81	2.01	148.1
Mathematics	5.68	8.32	46.5
Music	0.88	0.77	-12.5
Philosophy	1.89	2.86	51.3
Physics	12.30	9.72	-21.0
Political Science	3.08	4.06	31.8
Pre-dentistry	0.43	0.25	-41.9
Pre-medicine	7.10	3.74	-47.3
Psychology	1.11	2.59	133.3
Sociology	0.33	0.70	112.1
Speech	.30	0.25	-16.7
Number	3,960	4,432	
Number Undecided	497	25	
Total Number	4,457	4,457	

Source: Robert C. Nichols, "Career Decisions of Very Able Students," Science, 12 June 1964.

certain that such declines will occur. It is possible that science and engineering have been oversold as careers to the most able students. High-school students may be becoming immune to the shock effects of special courses, scholarships, the Science Talent Search, and the glamour of the space age, as a result, many of the less sure and dedicated science students who in 1957 would have chosen science and engineering and then later transferred to other major fields and careers in 1963 may simply be listing themselves as undecided, or may even be expressing career and major field preferences which are more realistic in terms of their long-run interests and abilities.

Occupation and Major. The two principle sources of recent information about the relation of actual occupation and college majors are surveys of 1951 college graduates in 1952 and 1958 graduates in 1960 that were conducted for the National Science Foundation (13) and (14). Although these studies were conducted by different agencies and are not comparable, they provide much useful information about the activities of new college graduates. Because of the difference in the time elapsed since graduation in the two studies and the sharp reduction in proportions in military service from 1952 to 1960, it is not possible to make reliable statements about trends.

Another difficulty arises in the classification of graduates into full-time students and employed persons in 1952 (Table 13) and into students not employed and employed persons in 1960 (Table 14). The data in Table 14 for 1960 tends to understate the amount of postgraduate enrollment and to dilute the occupational specialization of graduates with part-time teaching and research employment which does not represent the full-time or career employments of the graduates.

Table 13
Male Engineering and Science First Degree
Graduates in 1951 by Occupation in 1952
(Percentages)

Major Subject of Degree	Percent of Total: Total	Full-Time Students	Active Military Duty	Employed in: Total	Natural Science	Engineering	Unemployed	Other	Percent of Total In Same Occupation and Major	Percent of Employed In Same Occupation and Major
Natural Science	100.0	35.9	17.7	44.1	19.9	5.4	1.5	0.8	16.8[a]	45.0[a]
Chemistry	100.0	40.9	17.0	40.4	29.5	2.4	1.0	0.7	27.8	68.9
Physics	100.0	28.3	15.0	55.3	25.3	22.2	1.2	0.6	22.8	41.2
Mathematics	100.0	16.1	24.4	57.1	9.7	10.2	1.4	1.0	6.8	11.9
Earth Science	100.0	17.4	24.9	54.8	35.5	6.4	2.2	0.7	33.7	61.6
All Other	100.0	46.2	14.6	36.5	12.1	1.6	1.9	0.9	7.6[b]	20.8[b]
Engineering	100.0	4.1	17.6	77.1	1.9	70.6	0.5	0.7	60.8[c]	78.9[c]
Aeronautical	100.0	1.7	19.8	78.5	---	76.0	0.0	0.0	70.2	89.5
Chemical	100.0	10.1	14.4	75.0	8.3	65.3	0.2	0.0	59.2	78.9
Civil	100.0	3.2	19.9	75.7	0.8	72.7	0.3	0.9	62.6	82.7
Electrical	100.0	3.7	12.1	82.9	0.5	79.5	0.5	0.6	74.0	89.2
Mechanical	100.0	3.4	17.3	78.2	0.2	74.4	0.5	0.7	58.1	74.3
All Other	100.0	3.9	22.8	71.7	3.7	57.9	0.6	0.9	49.5[d]	69.0[d]
All Other	100.0	14.9	22.1	60.4	1.0	1.7	1.6	0.9	----	---
TOTAL	100.0	16.1	20.7	60.9	3.6	13.4	1.4	0.9	----	---

a. Weighted average of percentages for detailed natural science field.
b. Percentage of "all other" natural science graduates employed in "all other" natural science jobs.
c. Weighted"average of "percentages for detailed engineering fields.
d. Percentage of "all other" engineering graduates employed "all other" engineering jobs.

Source: Appendix Table 4 .

The percentages shown in Tables 13 and 14 show that the relation between undergraduate major and occupation is very strong for engineers but much less strong for physical science and mathematics majors. Of those 1951 engineering graduates that were employed in 1952, about 90 percent were employed in engineering and 3 percent were employed in natural science. The proportion of persons employed that had the same occupation and undergraduate specialty ranged from 74 percent for mechanical engineers to 89 percent for electrical and aeronautical engineers. About 79 percent of employed chemical engineering graduates were working as chemical engineers. Similar data for 1960 show a range from 51 percent for chemical engineers to 87 percent for electrical engineers. It is not possible to estimate what percentage of 1958 engineering graduates in the various specialties were working as engineers in 1960, but 80 percent of all 1958 engineering graduates were working as engineers in 1960. Considering the inclusion of full-time students with part-time jobs in 1960, this does not necessarily represent a decline in occupational specialization. The relatively low level of specialization of chemical engineering graduates in chemical engineering jobs in both years is worth noting since chemical engineering employment increased only 31 percent over the period 1950-60 while employment of all engineers increased 66 percent. (according to Census data). Similarly the high occupational attachment of electrical engineering graduates is consistent with the more rapid growth of electrical engineering employment (73 percent) over the period.

That only one-half of the employed chemical engineering graduates in 1958 were working as chemical engineers in 1960 does not necessarily imply that a high degree of specialization in undergraduate training is undesirable, but

Table 14

Male Engineering and Science First
Degree Graduate in June, 1958 by Occupation in May, 1960
(Percentages)

		Percent of Total							
				Employed in					
Major Subject of Degree	Total	Students not working	Active Military Duty	Total	Natural Science	Engineering	Other	Percent of Total in Same Occupation and Major	Percent of Employed in Same Occupation and Major
Natural Science	100.0	---	---	62.9	13.3	6.4	---	---	---
Chemistry	100.0	22.7	9.5	64.9	24.0	3.9	2.9	23.0	35.4
Physics	100.0	15.5	10.9	71.5	18.2	24.5	2.1	17.0	23.7
Mathematics	100.0	6.6	13.1	77.0	12.7	9.8	3.3	10.6	13.8
Earth Sciences	100.0	6.5	6.5	69.9	19.0	7.2	2.0	13.7	19.6
All Other	100.0	---	----	52.2	5.7	1.6	---	---	----
Engineering	100.0	3.0	13.5	82.0	0.9	65.3	1.4	---	79.6
Aeronautical	100.0	----	---	----	----	----	----	----	----
Chemical	100.0	---	---	----	---	----	---	42.0	51.3
Civil	100.0	---	----	----	---	----	----	61.7	75.4
Electrical	100.0	----	----	----	----	---	---	71.0	86.6
Mechanical	100.0	----	----	---	---	----	----	54.5	66.5
Mining	100.0	----	---	---	----	---	----	36.9	44.9
Industrial	100.0	----	---	----	---	---	----	28.9	35.5
All Other	100.0	---	----	----	---	---	---	----	----
All Other	100.0	---	---	75.0	2.3	1.3	----	---	---
TOTAL	100.0	10.1	13.2	74.3	4.0	1.0	2.4	---	---

Source: Appendix Table 5.

it certainly suggests that much of the specialized training of many chemcial engineering students is never used.

The occupational attachment of physical science and mathematics majors was much less in both years than that of engineers. In both years about one-fourth of the employed chemistry graduates worked as chemists in both years, about one-fifth of the employed physics graduates worked as physicists, and one-tenth of the employed mathematics graduates worked as mathematicians. In both years about one-fourth of the employed physics graduates and about one-tenth of the employed mathematics graduates worked as engineers. In other words, engineering was just as important as physics as an occupation for physics graduates and just as important as mathematics as an occupation for mathematics graduates.

The implications of these figures for projections of scientific and engineering manpower supply should be obvious. The occupational specialization of science and mathematics graduates is such that far more graduates are produced than are ever employed in the same occupational specialty. Many of the chemistry, physics, and mathematics graduates never work in jobs as chemists, physicists, or mathematicians. Unless the demand for college and secondary school teachers and engineers is taken into account the supply of physical science and mathematics graduates may appear adequate when it is actually inadequate to meet all demands.

VI. Non-Graduate Engineers

Almost one-half of the persons reporting themselves as engineers in the 1960 Census of Population were not college graduates. (Table 15). No doubt some of these self-reported engineers are mere technicians, rather than engineers, but it is impossible to say how many. A survey of three aerospace

Table 15

Number of Engineers and Graduate Engineers by Specialty, 1950-60

Specialty	All Engineers		Graduate Engineers[a]			Nongraduate Engineers		
	Number	% Change Over Preceding Decade	Number	% Change Over Preceding Decade	Percent of All Engineers	Number	% Change Over Preceding Decade	Percent of All Engineers
Total								
1940	255,480	-----	155,760	-------	61.0	99,720	-----	39.0
1950	527,190	106.4	281,670	80.8	53.4	245,520	146.2	46.6
1960	869,716	64.2	482,729	71.4	55.5	386,987	57.6	44.5
Civil								
1940	86,140	-----	51,000	-----	59.2	35,140	------	40.8
1950	123,600	43.5	64,950	27.4	52.6	58,650	66.9	47.4
1960	159,809	29.3	86,025	32.4	53.8	73,784	25.8	46.2
Electrical								
1940	55,440	-----	33,540	----	60.5	21,900	----	39.5
1950	106,920	92.9	57,960	72.8	54.2	48,960	123.6	45.8
1960	183,151	71.3	106,787	84.2	58.3	76,364	56.0	41.7
Mechanical								
1940	82,920	----	49,120	-----	59.2	36,800	-----	40.8
1950	109,620	32.2	54,660	11.3	49.9	54,960	49.3	50.1
1960	160,069	46.0	86,025	57.4	53.7	74,044	34.7	46.3
Chemical								
1950	31,620	----	25,710	----	81.3	5,910	----	18.7
1960	40,846	29.2	34,829	35.5	85.3	6,017	1.8	14.7
Aeronautical								
1950	17,850	----	10,230	----	57.3	7,620	----	42.7
1960	51,463	188.3	30,793	201.0	58.5	20,670	171.3	41.5
Industrial								
1950	41,100	-----	18,060	----	43.9	23,040	----	56.1
1960	97,071	136.2	41,992	132.5	43.3	55,079	139.1	56.7
Metallurgical								
1950	12,690	-----	7,320	----	57.7	5,370	----	42.3
1960	19,046	50.1	12,007	64.0	63.0	7,039	----	37.0

Table 15
(continued)

Number of Engineers and Graduate Engineers by Specialty, 1950-60

Specialty	All Engineers: Number	All Engineers: % Change Over Preceding Decade	Graduate Engineers[a]: Number	Graduate Engineers[a]: % Change Over Preceding Decade	Graduate Engineers[a]: Percent of All Engineers	Nongraduate Engineers: Number	Nongraduate Engineers: % Change Over Preceding Decade	Nongraduate Engineers: Percent of All Engineers
Mining								
1950	11,340	------	7,470	-----	65.9	3,870	------	34.1
1960	12,203	7.6	9,036	21.0	80.6	3,163	18.2	19.4

a. Four or more years of college.

SOURCE:

U. S. Census of Population 1950, Special Report P-E No. 1B, Occupational Characteristics, Table 6, pp. 1B-69, 1B-75.

U. S. Census of Population 1960, Subject Report PC (2)-7A, Occupational Characteristics, Table 2, p. 11; Table 6, pp. 71, 81.

companies by Shapero et al. (17) showed that about 30 percent each of their new hires of engineers and employed engineers were non-graduates. Similarly the relatively high present values of lifetime earnings of non-graduates reporting themselves as engineers also indicate that many of them have professional qualifications that earn them large salaries. (Table 16). For comparative purposes it may be noted that at 6 percent, four-year college graduates have present values of lifetime earnings of

Chemists	$114,897
Physicists	137,090
Secondary School Teacher	78,419

so that the following present values of lifetime earnings of high-school graduate engineers look quite good:

Technical (total)	$115,030
Aeronautical	125,631
Civil	100,452
Electrical	117,755
Mechanical	122,833
Sales	129,139

It is widely recognized that college graduation is the appropriate minimum entrance requirement to engineering, but employers have not always been able to hire as many engineers as they might like at the salaries they are willing to pay (see Folk (7)). As a result there is some tendency for engineering specialties such as aeronautical and electrical engineering in which demand (and, consequently, employment) have been growing most rapidly to maintain a proportion of nongraduates, that falls slowly, while slowly growing specialties such as chemical and mining engineering have more rapidly falling proportions of nongraduates. The rank correlation between the change in percent nongraduate and rate of change in graduate employment, although not highly significant confirms the statement. ($r_s = 0.48$. For $P = .05$, $r_s - 0.641$.) The interdependence of the rates of change of employment of graduate engineers and of

Table 16

Present Values at 6 % of Estimated Lifetime
Earnings of Men in Selected
Engineering Specialties, by Years
of Education

Engineering Specialties	High School 1-3 Years	High School 4 Years	College 1-3 Years	College 4 Years	College 5 or More
Technical (total)	109,815	115,030	120,691	138,127	145,732
Aeronautical	111,122	125,631	132,075	145,778	150,281
Civil	97,734	100,452	110,141	132,871	134,316
Electrical	113,520	117,755	121,508	139,131	151,225
Mechanical	115,903	122,833	125,760	136,630	143,196
Sales	133,032	129,139	145,612	149,824	151,015

Source: Hugh Folk, "Present Values of Lifetime Earnings of College Occupations," Department of Economics, Washington University, St. Louis, Working Paper 6509, June 1965, Appendix Table 2.

nongraduate engineering is indicated by their high rank correlation (r_s = .96, $p > .01$).

Despite the growth of nongraduate engineers in number, however, it should be noted that the proportion of graduates has increased in all specialties except industrial engineering. The "shortage of engineers" of the 1950's did not lead to a reduction in the proportion of engineers that were graduates over the period 1950-1960.

VIII. Summary and Conclusions

The conclusions which we may draw from the foregoing analysis may be listed:

(1) The percentage of male first time enrollment in engineering reached at a peak in 1957 and fell to an all-time low in 1962.

(2) There is little evidence that the Bureau of Labor Statistics forecast of a decline in engineering employment opportunities made in 1949 had a large or lasting effect on engineering freshman enrollments.

(3) While the proportion of all male college graduates in physical science and engineering has remained approximately constant over the period 1949 to 1962; of all male graduates in mathematics has risen sharply since 1957.

(4) Levels of engineering and science enrollments and degrees have reflected the growth in the number of high-school graduates entering college and the fluctuations in the number of veterans.

(5) Retention rates and the relation of graduates to earlier year enrollments show low stability so that it is impossible to make reliable forecasts of engineering graduates from current year enrollments.

(6) Engineering starting salaries have increased steadily as a percentage of general business trainees starting salaries, while chemists' starting

salaries have declined as a percentage of general business trainees' starting salaries over the period 1952-62.

(7) The observable occupational training supply curve of engineers estimated from postwar data would be backward sloping; i.e. the increasing salary ratio of engineers to others has been accompanied by an increased percentage of high-school graduates entering engineering. Hence, it cannot be said that increased relative salaries will increase the proportion of the relevant group of students choosing engineering.

(8) Over the past 30 years there has been little change in the prestige ranking of engineering relative to other occupations commonly entered by college graduates.

(9) Veterans show a somewhat higher propensity to enroll in engineering than nonveterans, but the decline in the number of veterans attending college accounts for about 17 percent of the decline over the period 1949-1963.

(10) About one-half of the seniors that as freshmen aspired to engineering as a career anticipate engineering careers.

(11) Over one-half of the very able freshmen choosing engineering and science as careers change career anticipations by their senior year.

(12) Men graduating in engineering and science do not all enter engineering or science jobs; the proportion of engineering graduates entering such jobs is much higher than the proportion of men with science degrees.

(13) Over the period 1950 to 1960, the rate of change of the number of nongraduate engineers in the various specialties is highly correlated with the rate of change of the number of graduate engineers in the same specialties.

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Appendix Table 1

Percentage of Male National Merit Semi-Finalists
Choosing Various College Major
Fields, 1958-63

Major Field	1958	1959	1960	1961	1962	1963
Architecture	1.22	0.84	0.89	.92	1.12	1.26
Biology	0.86	1.63	1.37	1.31	2.53	3.02
Business	2.02	2.25	1.62	1.50	1.36	1.62
Chemistry	6.81	8.37	6.74	5.60	7.25	8.15
Engineering	29.59	27.44	26.63	23.51	17.76	19.88
Aeronautical	2.75	2.27	2.45	1.91	1.94	1.92
Chemical	5.83	5.45	5.62	4.06	3.06	3.08
Civil	1.77	1.93	1.53	1.63	1.22	1.24
Electrical	10.36	9.07	8.79	7.73	5.58	6.94
Mechanical	3.81	3.71	3.40	2.78	2.15	2.55
English	3.22	2.58	3.08	3.16	3.43	4.17
Geology	0.61	0.65	0.66	0.32	0.30	0.20
History	1.78	1.63	1.69	1.97	2.43	3.30
Journalism	0.80	0.79	0.82	0.79	0.64	0.53
Language	0.65	1.20	1.28	1.16	1.41	1.27
Mathematics	8.40	11.40	12.18	13.36	14.03	16.04
Philosophy, Religion	1.84	1.62	1.58	1.75	1.26	1.77
Physics	18.80	16.38	16.44	14.66	14.20	12.23
Pre-Medicine	8.12	6.90	6.79	8.58	7.12	6.96
Psychology	0.96	0.95	0.98	1.00	0.98	1.32
Social Sciences	7.30	7.21	9.10	11.44	10.74	10.14
Number	5,096	6,439	6,847	6,179	6,042	6,598
Undesided	111	294	261	646	909	884
Total Number	5,207	6,733	7,108	6,825	6,951	7,482

Source: Robert C. Nichols, "Career Decisions of Very Able Students," Science, Vol. 144, 12 June 1964, P. 1316, Table 4.

Appendix Table 2

Percentage of Male National Merit Semi-Finalists
Choosing Various Careers, 1957-1963

Career Choice	1957	1958	1959	1960	1961	1967	1963
Architecture	----	1.25	0.97	1.00	1.12	1.30	1.53
Business	5.19	4.54	3.85	3.20	3.26	3.35	3.03
Engineering	33.60	25.46	28.52	28.05	24.61	18.17	20.82
Farming	----	0.14	0.14	0.14	0.12	0.22	0.17
Government Service	2.13	2.07	1.80	2.64	3.90	3.86	2.80
Law	6.45	5.32	6.24	7.00	8.83	7.57	9.36
Medicine	9.10	9.28	10.08	8.50	10.30	11.87	12.24
Ministry	1.95	1.97	1.83	1.43	0.92	1.18	1.73
Physchology	0.77	0.52	0.65	0.56	0.62	0.51	0.75
Scientific Research	28.66	37.77	31.21	31.79	29.57	32.62	28.87
Social Work	0.16	0.08	0.23	----	0.18	0.14	0.15
Teaching	7.95	8.45	10.31	12.32	13.35	14.93	15.14
Writing	1.80	2.29	1.78	1.85	2.34	2.08	2.12
Other	2.21	0.84	2.35	1.34	0.76	2.02	1.25
Number	4,930	5,019	6,178	6,628	5,637	5,524	6,001
Undesided	297	188	555	480	1,188	1,427	1,481
Total Number	5,527	5,207	6,733	7,108	6,825	6,951	7,482

Source: Robert C. Nichols, "Career Decisions of Very Able Students," **Science**, Vol. 144, 12 June 1964, P. 1316, Table 2.

Appendix Table 3

Enrollment of Men in Higher Education
and Engineering, by Veteran Status, 1948-63

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Male Enrollment in Higher Education			Undergraduate Enrollment in Engineering		
Year	Total	Veteran	NonVeteran	Total	Veteran	Nonveteran
1948	1,712,283	1,024,924	687,359	236,370	158,325	67,792
1949	1,728,672	851,290	877,382	201,927	120,402	81,525
1950	1,569,322	569,396	999,926	161,592	71,939	89,653
1951	1,398,735	402,467	996,268	145,997	47,132	98,865
1952	1,387,094	238,946	1,148,148	156,080	35,277	120,803
1953	1,432,474	281,776	1,150,698	171,725	34,379	137,346
1954	1,575,227	372,372	1,202,855	193,692	54,519	139,173
1955	1,747,429	458,664	1,288,765	221,448	69,111	152,337
1956	1,927,863	477,904	1,449,959	251,121	76,096	175,025
1957	2,003,424	445,388	1,558,038	268,761	73,882	194,879
1958	2,110,426	380,271	1,730,155	256,779	61,577	195,202
1959	2,173,793	271,345	1,902,450	242,992	42,850	200,142
1960	2,270,640	171,720	2,098,920	234,190	27,391	206,799
1961	2,423,487	101,125	2,322,862	232,104	15,754	216,350
1962	2,603,072	55,466	2,547,606	230,730	8,341	222,389

Sources: Column (1) U. S. Office of Education, Opening (Fall) Enrollments in Higher Education Institutions 1963, P. 3.

Column (2) 1948 and 1949 from U. S. Office of Education Biennial Survey of Education in the United States, 1956-58, OE50023-58, P. 47, t. 59. October to March of year averages, 1950-63 from U. S. Office of Education, Opening (Fall) Enrollments in Higher Educational Institutions Fall, 1963, P. 3, t. 2.

Column (4) 1954-63: U.S. Office of Education, Advance Reports on Engineering Degrees (1962) and Enrollments (1963), OE54004-63. 1949-53: U.S. Office of Education, Engineering Enrollment and Degrees, 1957, Circ. No. 516, p. 5, t. 1, 1948: Biennial Survey of Education 1948-50 reported in Engineering Enrollments and Degrees, Circ. 364, 1953 cited in David M. Blank and George Stigler, The Demand and Supply of Scientific Personnel.

Column (5) Unpublished data furnished by the U.S. Veterans Administration. Enrollment as of November 30 of each year.

Appendix Table 4

Male Engineering and Science First Degree Graduates

in 1951 by Occupations in 1952

(Number of Respondents)

				Employed				
					Natural Science			
Major Subject of Degree	All Respondents	Fall-time Students	Active Military Duty	Total	Total	Chemistry	Physics	Mathematics
Natural Science	4,024	1,443	714	1,774	799	364	92	44
Chemistry	1,050	429	179	424	310	292	2	1
Physics	360	102	54	199	91	2	82	-
Mathematics	590	95	144	337	57	11	3	40
Earth Science	409	71	102	224	145	2	-	2
All Other	1,615	746	235	590	196	57	5	1
Engineering	4,758	197	839	3,667	90	34	1	16
Aeronautical	121	2	24	95	-	-	-	-
Chemical	424	43	61	318	35	28	-	-
Civil	773	25	154	585	6	-	-	-
Electrical	1,095	40	132	908	5	-	1	-
Mechanical	1,209	41	209	945	2	-	-	1
All Other	1,138	44	259	816	42	6	-	15
All Other	20,342	3,039	4,490	12,290	194	87	7	7
TOTAL	29,124	4,679	6,043	17,731	1,050	452	100	67

Source: National Science Foundation, Education and Employment Specialization in 1952 of June 1951 College Graduates, Washington: U.S. Government Printing Office, 1955; tables B-2 and C-2.

Appendix Table 4 (continued)

Male Engineering and Science First Degree Graduates

in 1951 by Occupations in 1952

(Number of Respondents)

Activity in 1952

Employed												
Natural Science		Engineering										
Earth Science	All Other	Total	Aeronautical	Chemical	Civil	Electrical	Mechnical	All Other	Other	Unem-ployed	Other
158	141	217	12	21	15	53	21	95	758	61	32
5	10	25	-	17	2	2	1	3	89	11	7
5	2	80	6	1	1	37	6	29	28	3	2
-	3	60	6	-	4	10	10	30	220	8	6
138	3	26	-	3	3	2	1	17	53	9	3
10	123	26	-	-	5	2	3	16	368	30	14
29	10	3,360	175	258	522	835	754	816	217	22	33
-	-	92	85	-	-	-	-	2	3	-	-
-	7	277	-	251	3	2	2	19	6	1	1
6	-	562	26	-	434	-	10	42	17	2	7
4	-	871	1	-	1	810	9	50	32	6	7
-	1	899	48	2	2	5	702	140	44	6	8
19	2	659	15	5	32	18	26	563	115	7	10
33	60	345	7	3	25	29	26	243	11,751	330	193
220	211	3,910	194	282	562	917	801	1,154	12,771	413	258

Appendix Table 5
Male Engineering and Science First Degree Graduates
in June 1958 by Occupations in May 1960
(Number of Respondents)

				Employed				
					Natural Science			
Major Subject of Degree	All Respondents	Students not Working	Active Military Duty	Total	Total	Chemistry	Physicist	Mathematician
Natural Science	3,266	---	---	2,053	435	179	64	67
Chemistry	692	157	66	449	166	159	1	2
Physics	330	51	36	236	60	0	56	2
Mathematics	573	38	75	441	73	3	6	61
Earth Sciences	306	20	66	214	58	2	0	1
All Other	1,365	---	---	1713	78	15	1	1
Engineering	3,817	115	516	3,131	36	11	5	8
Aeronautical	145			119[c]				
Chemical	288			236[c]				
Civil	515			422[c]				
Electrical	1,025			841[c]				
Mechanical	888			728[c]				
Mining	168			138[c]				
Industrial	418			343[c]				
All Other	370			303[c]				
All Other	13,316			9,981	344	15	1	15
TOTAL	20,399	2,070	2,684	15,165	815	205	70	90[a]

a. Adjusted to remove 5 actuaries. There were 95 mathematicians and actuaries of whom 66 were mathematics majors and 51 statisticians of whom 8 were mathematics majors (Table A-24). There were 61 mathematics majors that were mathematicians and 13 mathematics majors that were statisticians and actuaries (Table A-25.

b. Other and status not reported.

c. Estimated on the assumption that the employment rate is the same for all engineering specialties.

Appendix Table 5 (continued)
Male Engineering and Science First Degree Graduates
in June 1958 by Occupations in May 1960
(Number of Respondents)

Employed											
Natural Science		Engineering									
Geologist	All Other	Total	Chemical	Civil	Electrical	Mechanical	Mining	Industrial	All Other	Other	Other[b]
45	80	207	8	14	74	30	12	18	51	1,411	--
0	4	27	7	0	2	6	1	11	11	256	20
0	2	81	0	1	44	11	0	2	23	95	7
0	3	56	1	6	18	10	0	8	13	312	19
42	133	22	0	6	0	2	11	3	3	134	6
3	58	21	0	1	10	1	0	9	9	614	
1	11	2,493	147	381	790	670	84	203	218	602	55
						69					
			121								
				318		17					
					728	15			31		
				18	23	484		35	62		
							62		39		
					10	19		121	20		
---	---	170	8	15	25	17	1	48	56	9,467	
---	---	2,870	163	410	889	717	97	269	325	11,480	480

Source: National Science Foundation, Two Years After the College Degree NSF 3-26, 1963, tables A-23M, A-24, A-25.

Appendix Table 6
Undergraduate Major Field of June, 1958 Male Bachelor's Degree Recipients
and May 1960

Occupation	Total Number in Occupation[a]	Undergraduate Major Field: Natural Science: Total	Chemistry	Earth Science	Physics	Physical Science Misc.	Mathematics	Other	Engineering
Health Professions	407	57	14	1	1	2	1	38	8
Business Mgmt.	3,181	110	19	27	3	5	20	36	185
Agricultural Scientist	231	30	3	2	2	0	1	22	14
Biological Scientist	86	61	4	1	1	1	0	54	3
Geologist	-----	45	0	42	0	3	0	0	1
Physicist	70	64	1	0	56	1	6	0	5
Chemist	205	179	159	2	0	3	3	12	11
Physical Scientist All Other	-----	19	0	12	1	3	3	0	8
Teacher, College	464	152	44	13	30	6	32	27	65
Natural Science	(125)	(96)	(40)	NA	(20)	NA	(5)	(31)	(10)
Mathematics	(36)	(26)	NA	NA	NA	NA	(25)	(1)	(5)
Teacher, Secondary									
Natural Science	480	196	30	12	13	18	14	109	8
Mathematics	332	154	4	1	5	7	129	8	5
Engineer	(2,870)	(207)	(27)	(22)	(81)	(18)	(56)	(4)	(2,493)
Chemical	163	8	7	0	0	0	1	0	147
Civil	410	14	0	6	1	1	6	0	381
Electrical	889	74	2	0	44	8	18	2	790[b]
Mechanical	717	30	6	2	11	1	10	0	670
Mining	97	12	1	11	0	0	0	1	84[c]
Industrial	269	18	11	3	25	8	21	1	203
All Other	325	51	11	3	25	8	21	1	218
Mathematician	95	67	2	1	2	0	61	1	8
Statistician, Actuary	51	14	0	1	0	0	13	0	1
Programmer	45	18	1	1	3	1	12	0	4
Health Occup	119	72	15	1	1	3	3	49	3
Laboratory Assistant	81	55	24	5	3	1	1	21	6
Technician	50	15	NA	NA	NA	NA	NA	NA	NA
Research Assistant	336	144	49	6	16	8	9	56	51
TOTAL	15,019	2,053	449	214	236	97	441	616	3,131

Appendix Table 6 (continued)
Undergraduate Major Field of June, 1958 Male Bachelor's Degree Recipients
and May 1960

a. Detail does not add to total.

b. reported as 789 in Table A-25.

c. Reported as 205 in Table A-25.

Source: National Science Foundation _Two Years After the College Degree_, NSF 63-26. Table A-24 and A-25.